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A 500V 1A 1-Chip Inverter IC on SOI Wafer

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Abstract

A monolithic 500V 1A inverter IC has been developed with dielectric isolation IC process on SOI(Silicon on insulator) wafer. This inverter IC (TPD4005K) can drive a 60W DC brush-less motor with no photo-coupled devices. Three half-bridge configured IGBTs and FRDs(fast recovery diode) are on a chip. For production of this HV-IC the SOI wafer with silicon direct bonding technique has been applied.

Introduction

The DC brush-less motor have advantages of high torque per unit volume and of high efficiency to other types of motors. The DC brush-less motor is easy to control because of two proportional relations. One is between torque and driving current, and another is between turning velocity and applied voltage. DC brush-less motor has no mechanical contacts as 'brushes', so it shows high reliability. On the other hand, it needs expensive and complicated driving circuits. The complex circuits demand bigger body size than other simple motor systems. In spite of these week points, the using situations of DC brush-less motor will increase on merits of higher efficiency, smaller motor size and high accurate controllability.

A conventional driving circuit of DC brush-less motor needs six power devices of IGBTs or FETs and photo-coupled devices to isolate high-side driving circuit from ground voltage level. This type circuit also requires large assembling area. Hybrid IC(H-IC) is another solution to the area problem. But, H-IC is so expensive that H-IC

application is unusual.

1-Chip Inverter IC and Usage

The developed 1-chip inverter IC(TPD4005K) can drives DC brush-less motor which is less than 60W; for power reduction of air-conditioner's or hot water supply system's fan motors.

Fig.2 shows the circuit block diagram. The 3-phase full-bridge output devices(IGBTs and FRDs) and the inverter control circuit have been integrated on one chip. The inverter control circuit includes the high side drivers with high blocking voltage level shift circuits, the internal high side voltage sources with the bootstrapping technique, the internal logic level voltage regulator, the over current protection circuit, the over temperature protection circuit, and the low level voltage protection circuits of internal high side voltage regulators. This IC can drive a high voltage DC brush-less motor. It requires no photo isolators. (Fig.7)

Especially, the high side driver circuit with level shift system realized direct driving the high side IGBTs without any voltage shift circuit out of chip from CPU control signal. And three protection systems improved reliability of the DC brush-less motor driving system.

Fig.3 shows the typical motor driving waveform. Applied motor is for fan of air-conditioner. The hole sensor chips have been used to acquire the sensing signal of the position of rotor. The pulse wave modulation(PWM) signal has been applied to high side. Applied voltage on motor is 300V, PWM frequency is 4kHz, power duty is 40%. This IC can operate over 17kHz PWM frequency.

Dielectric Isolation IC Process

The dielectric isolation(DI) IC process has been applied to development of the 1-chip inverter IC. The DI process uses SOI wafer with trench isolation structure. SOI wafer was constructed with SDB(Si Direct Bonding) technique. Each devices are dielectrically isolated by the deep-trench structure. Thickness of active layer of Si is about 16 microns, and thickness of buried oxide film is about 3.5 microns.

Fig.1 shows a chip photograph of a fabricated 500V-1A inverter IC. The output elements are L-IGBTs and L-FRDs. The breakdown voltages of output devices are over 500V, and IGBT's maximum rating current is over 2A. The SRFP(Scroll shaped Resistive-Field-Plate) techniques have been applied to the high blocking voltage element in order to reduce the electrical field influence of metal layer. The fabricated IC requires

no lifetime control technique.

The forward voltage drop of IGBT(Vce(sat)) is 3.0Vmax at 1A output current point. The L-IGBT's switching form is shown on Fig.4. It shows 200nsec turn off time at Ic=1A and Vce=300V. Fig.5 shows L-IGBT's forward characteristics. Forward voltage drop is 2.5V at Ic=1A and Vg=5V.

Fig.6 shows the cross-section of the inverter IC. The high breakdown voltage devices and low breakdown voltage elements are fabricated on a chip.

[References]

H. Funaki, T. Matsudai, A. Nakagawa, N. Yasuhara, Y. Yamaguchi, "Multi-Channel SOI Lateral IGBTs with Large SOA", *Proc. of 9th ISPSD*, 1997, p.33.

K.Endo, Y.Baba, Y.Udo, M.Yasui, Y.Sano "A 500V 1A 1-Chip Inverter IC with a New Electric Field Reduction Structure", Proc. of 6th ISPSD, 1994, p.379.

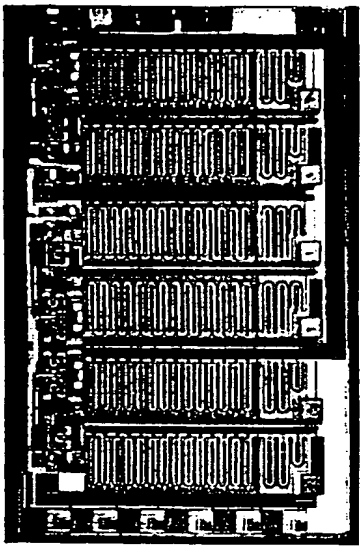

Fig.1 Chip Photograph

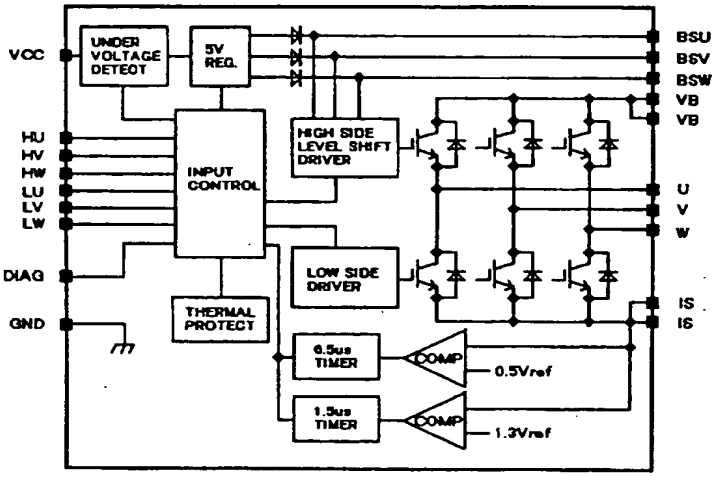

Fig.2 Circuit Block Diagram

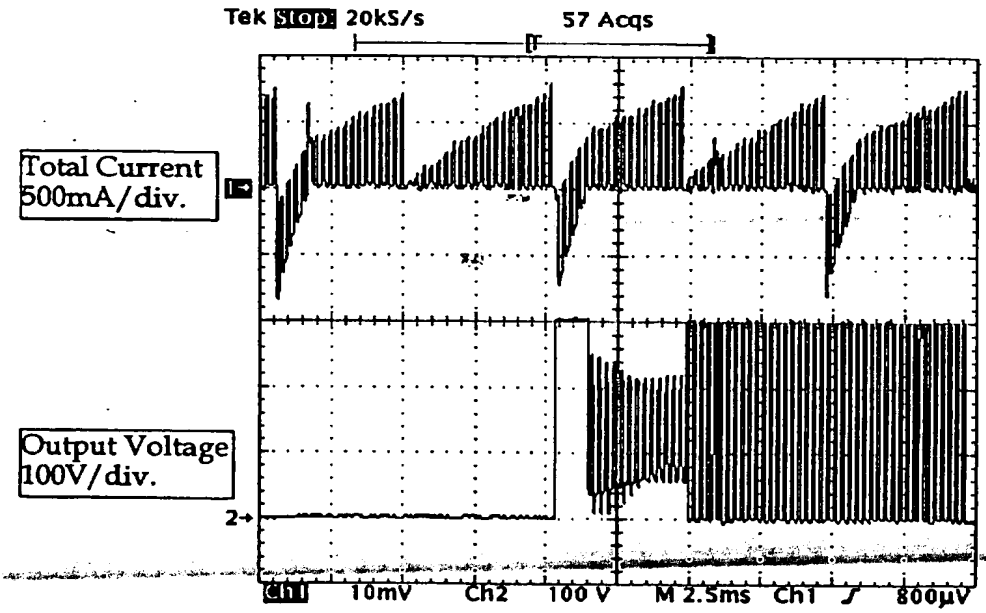

Fig.3 Typical Waveform

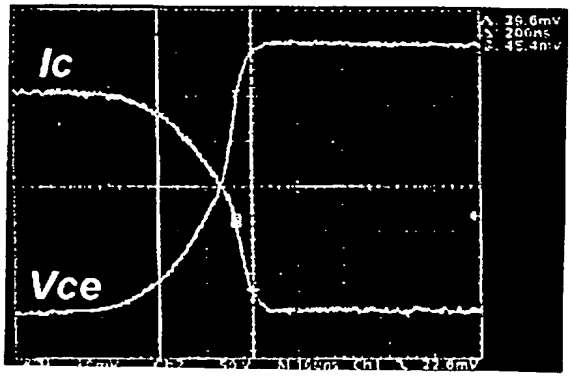

Fig.4 L-IGBT Switching form
Ic: 200mA/div. Vce: 50V/div.
100nsec/div.

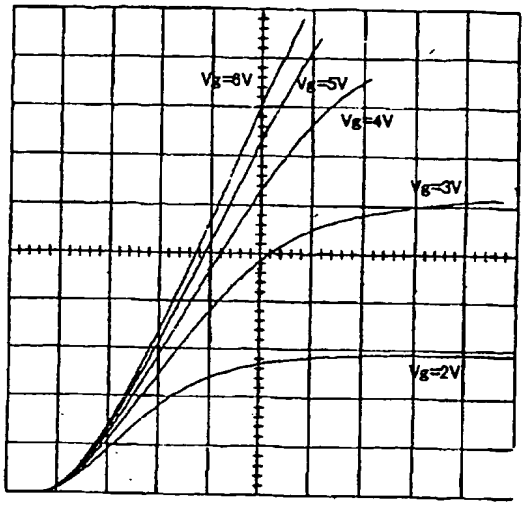

Fig.5 L-IGBT forward characteristics.
Voltage: 1V/div. Current: 500mA/div.

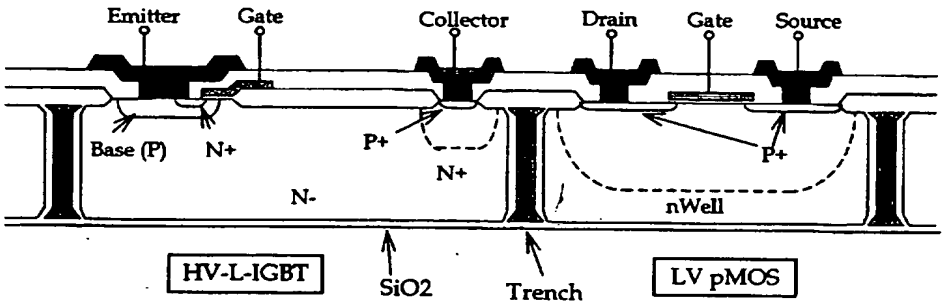

Fig.6 Cross-section of High Voltage IC Chip

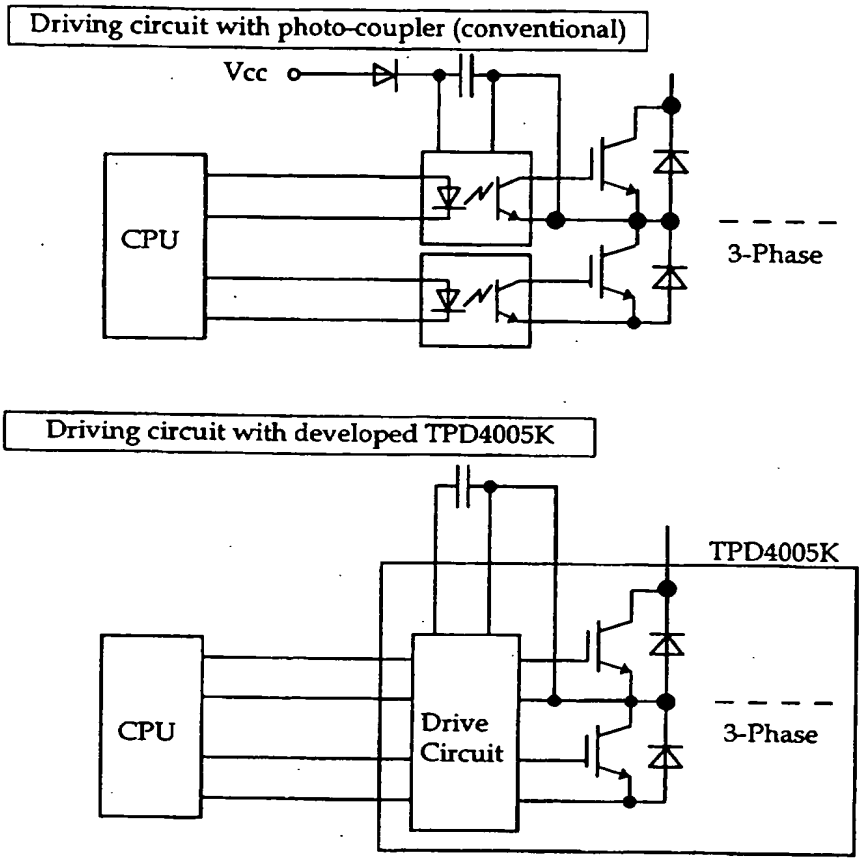

Fig.7 Conventional and Developed 1-Chip Inverter IC